S. Belomestnykh

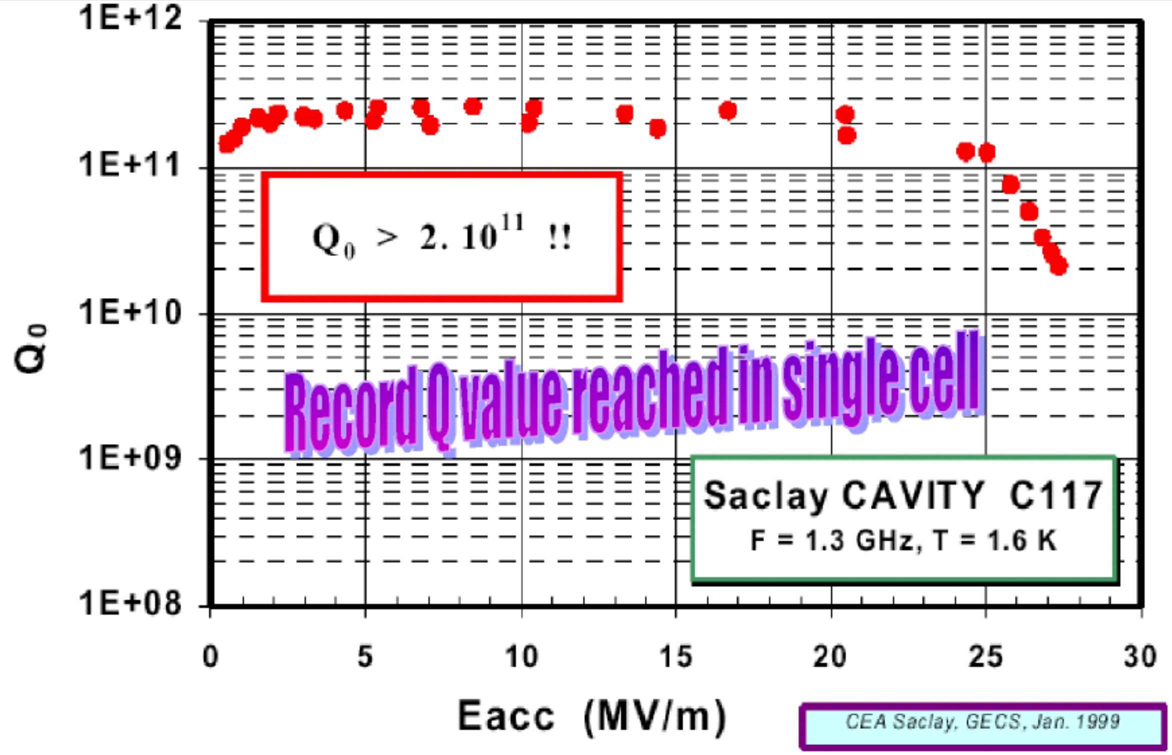
Superconducting RF for storage rings, ERLs, and linac-based FELs:

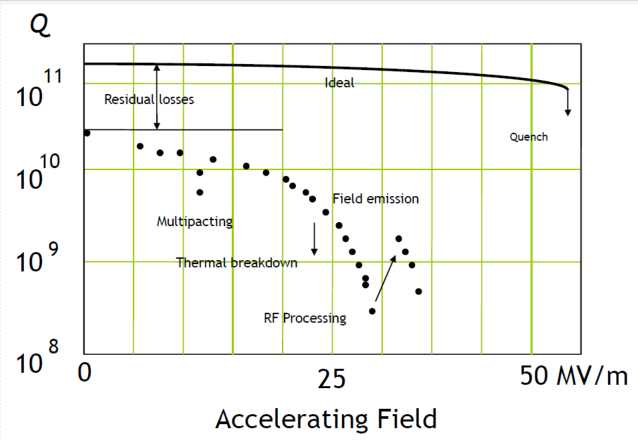
- Lecture 14 *Overview of remaining challenges*

Short list of most important challenges (personal view)

- Basic SRF studies:
  - Nature of residual resistivity and how to consistently achieve low R_{res} in cavities.
  - Nature of Q-slopes.
  - Theory & experimental studies of weak Type II RF superconductors (Nb): what is the RF critical magnetic field?
  - Alternative materials to bulk Nb.
- Cavity development:
  - New & alternative cavity geometries;
  - New ways to fabricate cavities.
- Other SRF technology challenges
- SRF guns

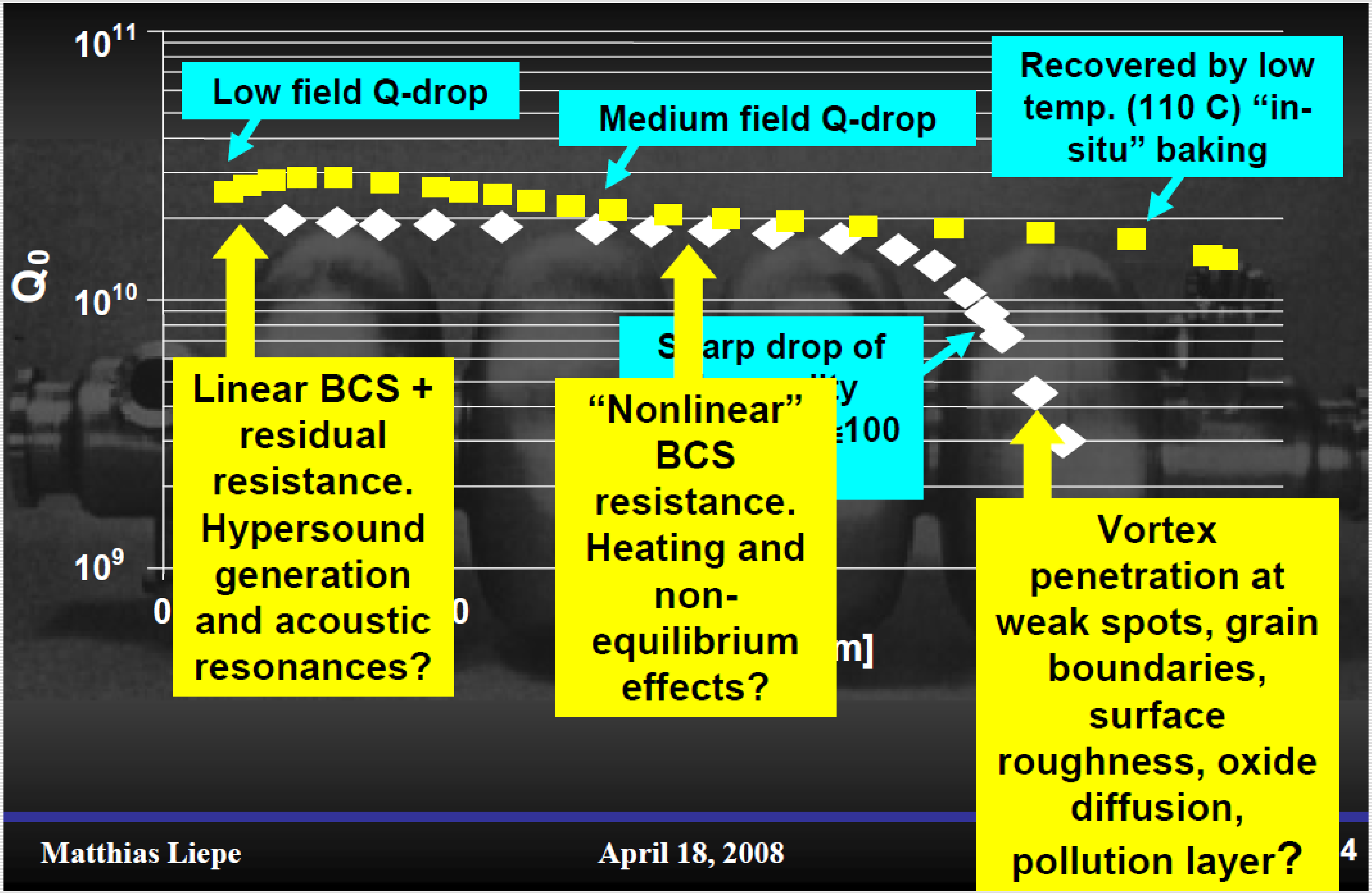
What causes R_{res}?





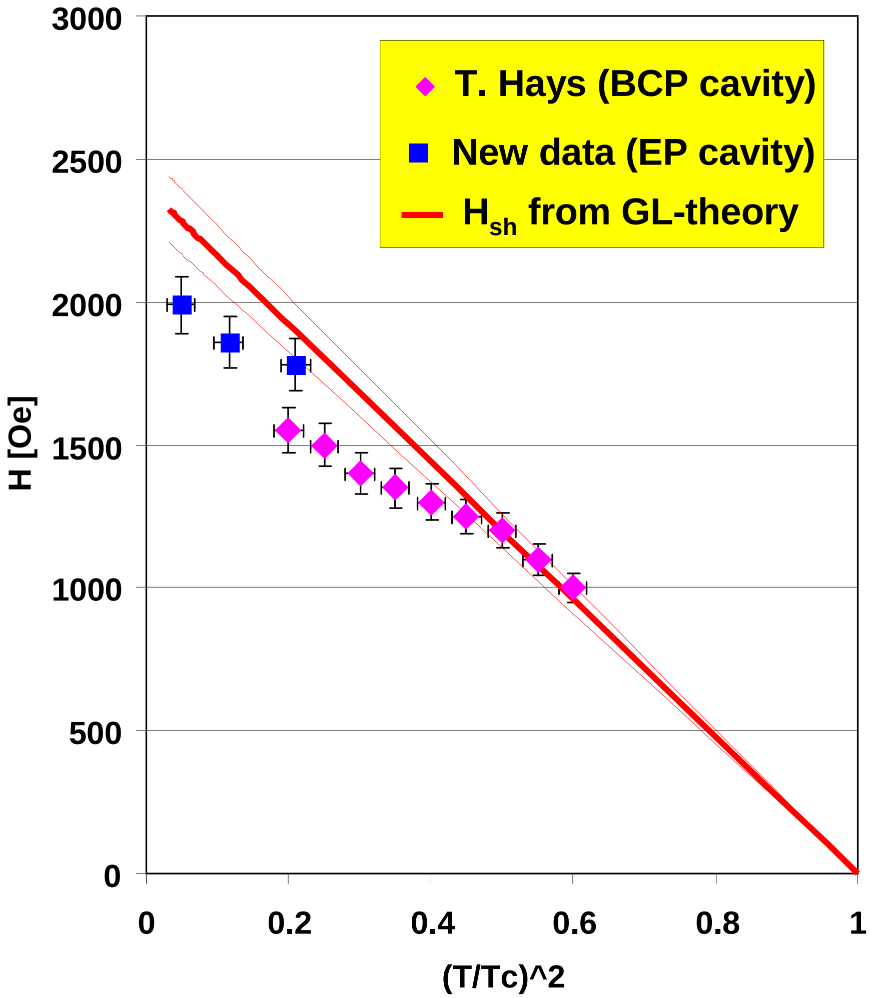
- Record Q reached so far, 2×10^{11} corresponds to R_s = 1.5 nOhm and R_{res} < 0.5 nOhm!
- What is the physics behind the residual resistivity?
- Why cannot all cavities be like this?

What is the nature of *Q*-slopes?

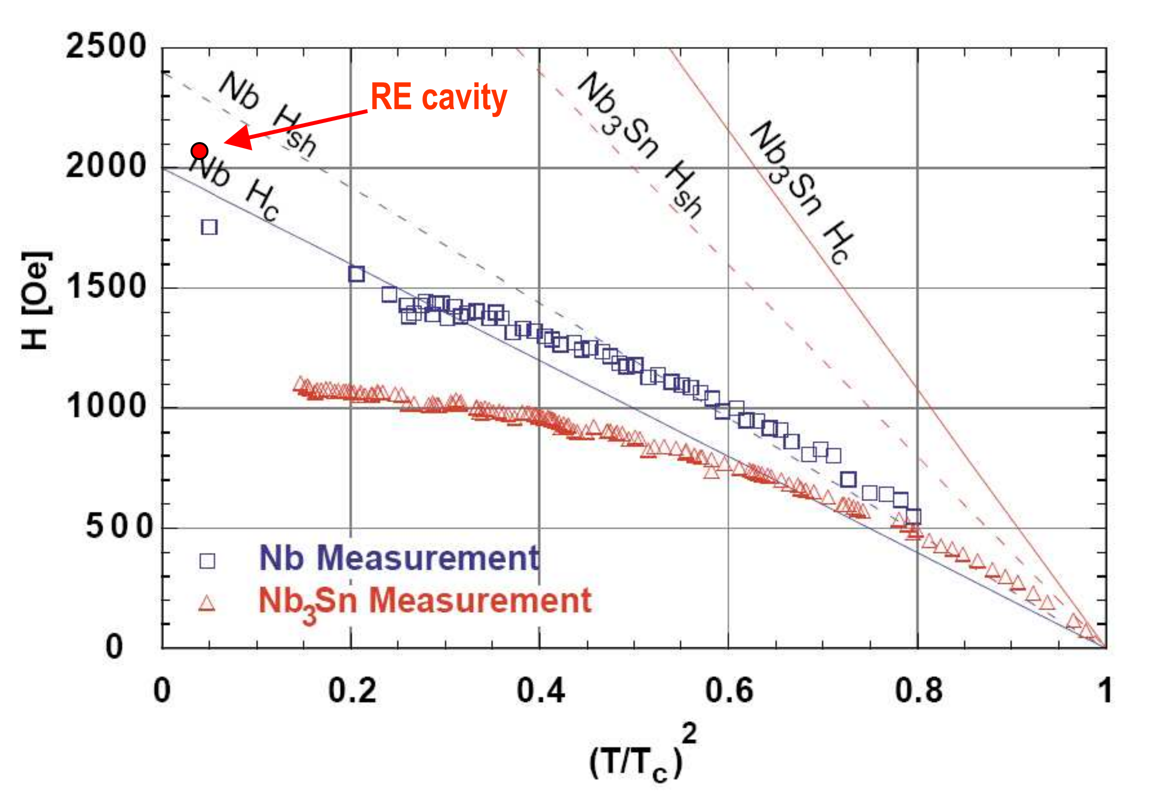


What is the critical RF magnetic field?

- Is it H_c, H_{sh}, H_{c3} or something else?
- We need advances in both theory and experiments to answer this question



Can we make other materials to work better than Nb?

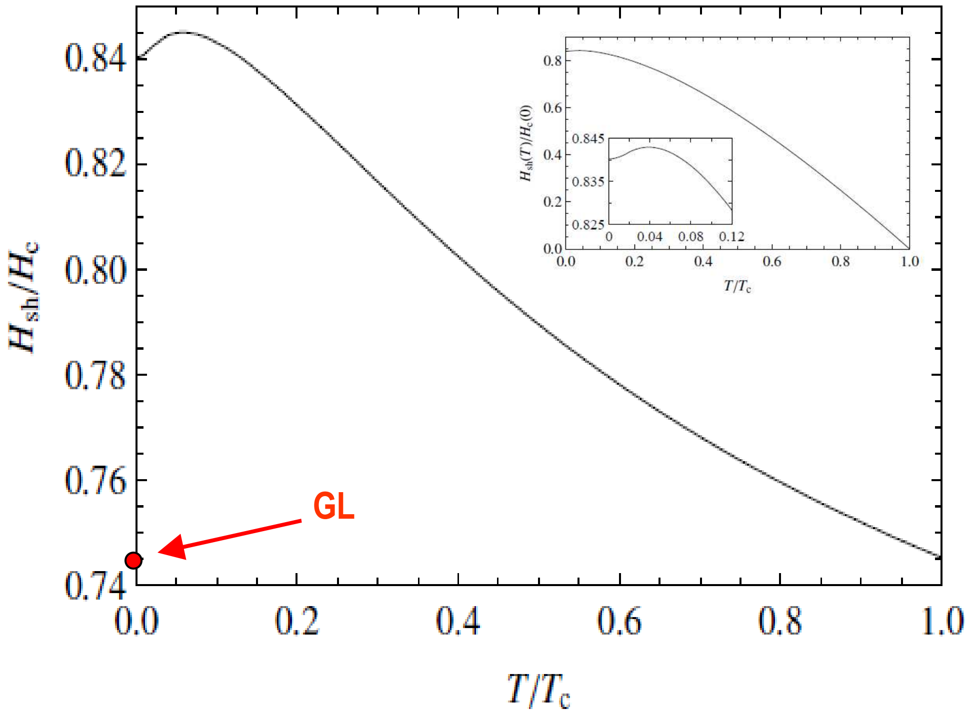


- Nb results are consistent with H_{sh}
- Nb_3Sn results fall short: Can we improve the quality of Nb_3Sn film and reach H_{sh}?

Recent theoretical advances

Superheating field $H_{sh}(T)$ from the Eilenberger Equations
And large κ (so not applicable for Nb)

13% larger ***Hsh*** at low ***T*** than Ginzburg-Landau estimate !



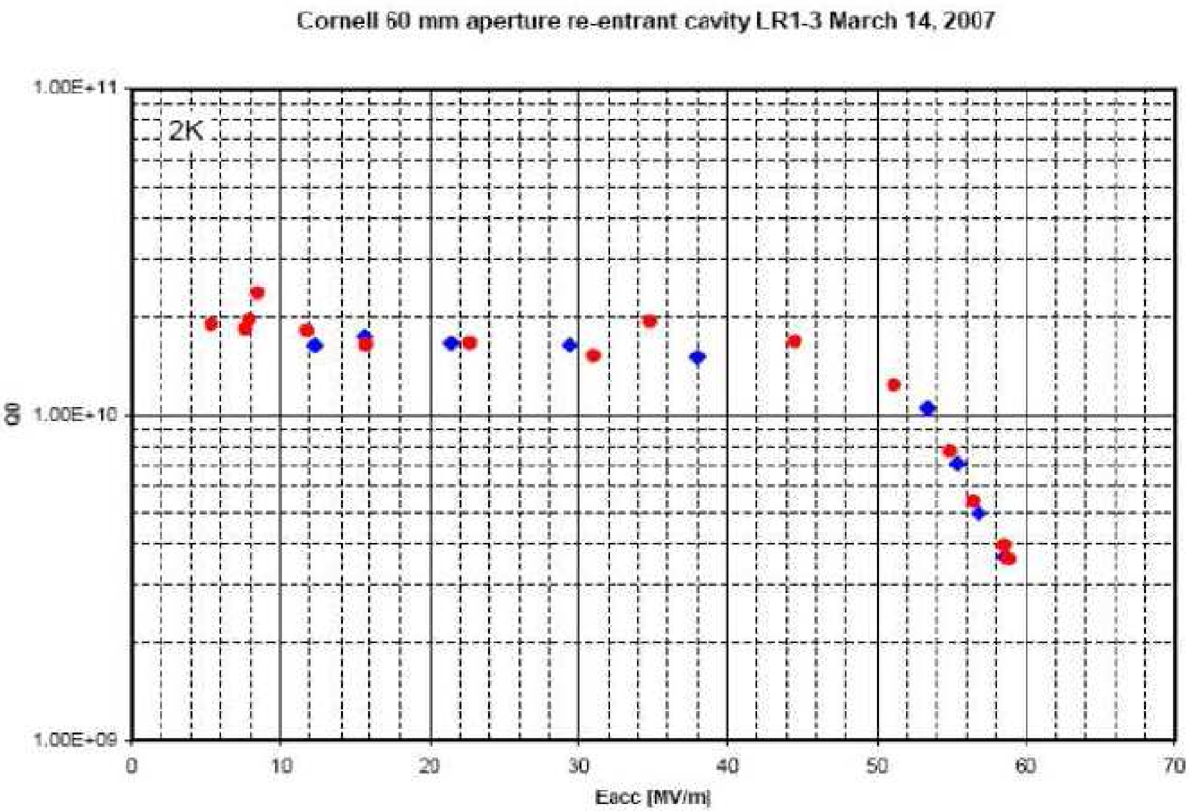
Hrf-critical = Hsh ~ 0.9 Hc

Which means

Theory gives hope for 100 – 200 MV/m !

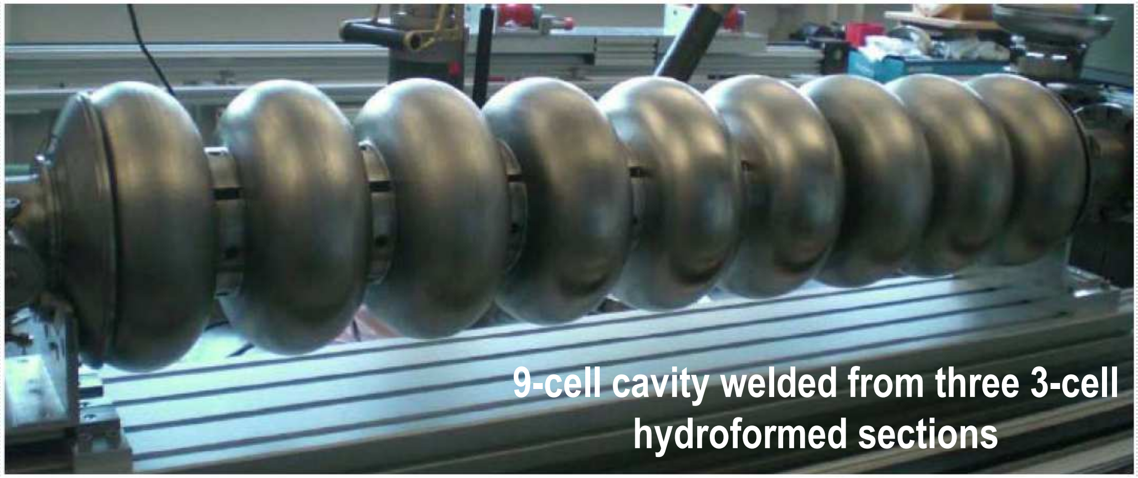
- Eilenberger (BCS) Theory predicts
- $\boldsymbol{E_{acc}}$ ~ 120 MV/m for perfect Nb_3Sn
- and 200 MV/m for perfect MgB_2 !!
- Strong motivation for materials and cavity push
- But be prepared for a long road to realization
- Can we do it?

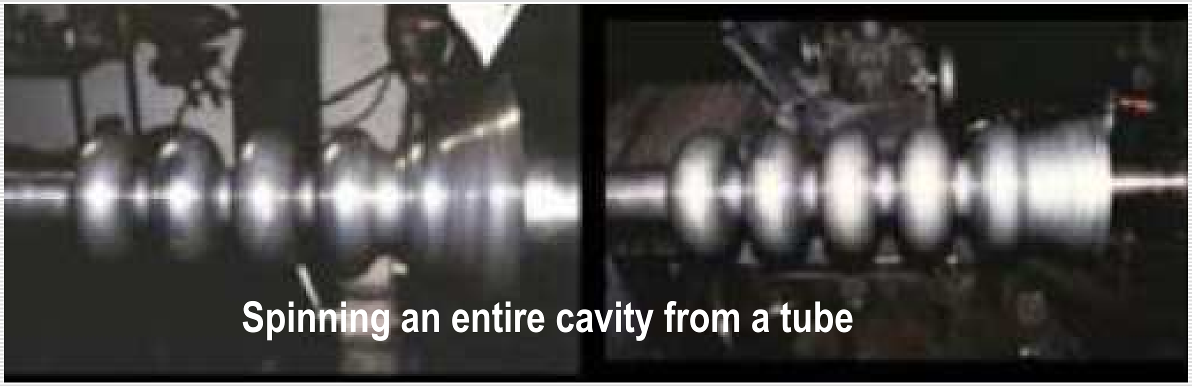
Can we reach these gradients in multicell cavities? Are there better geometries?



- E_{acc} = 59 MV/m corresponds to E_{pk} = 125 MV/m and H_{pk} = 2065 Oe at 2 K

Can we develop better (cheaper) fabrication techniques?



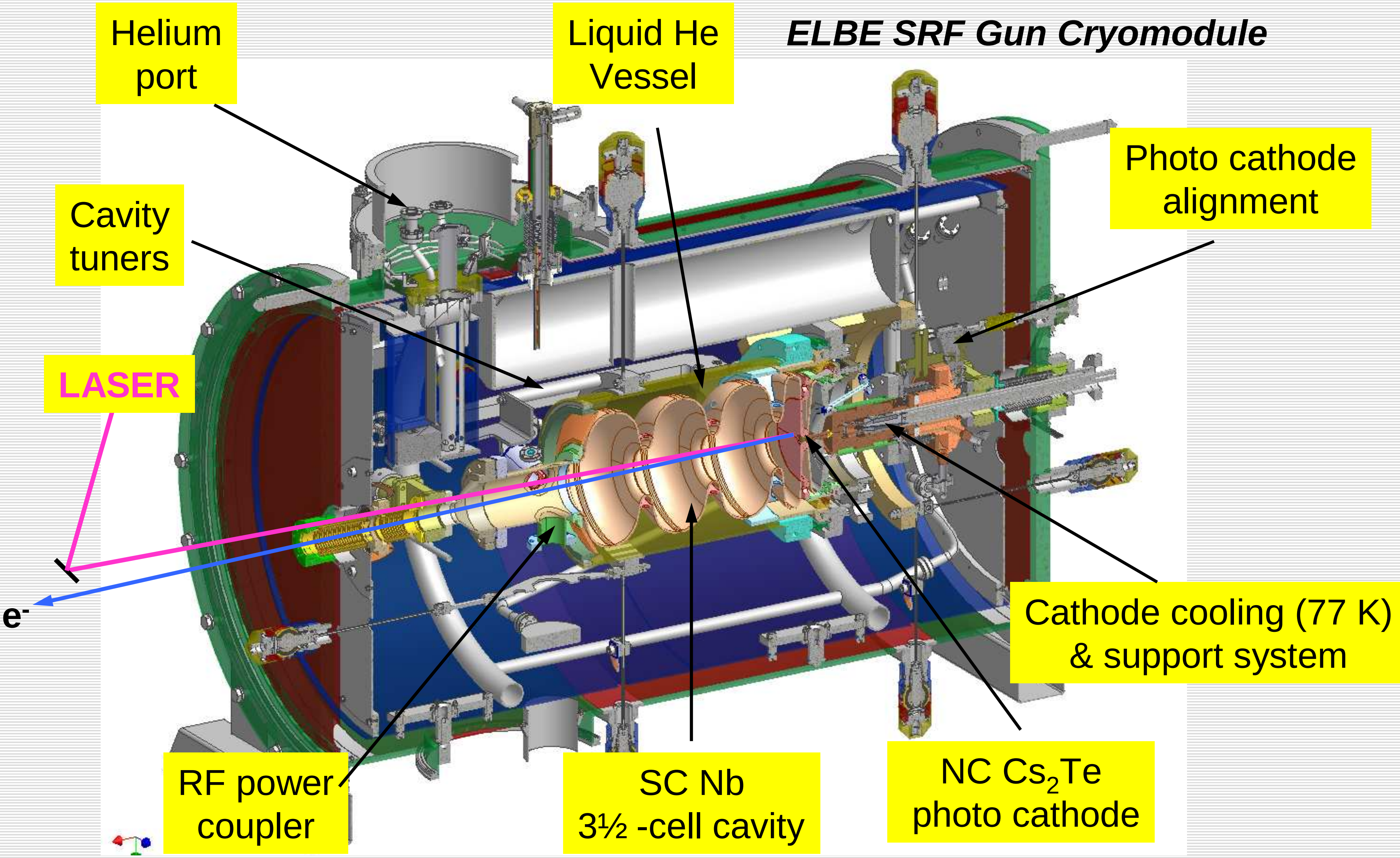


- Can we prove that this techniques produce cavities with good performance?
- Are they cheaper for mass-production?
- Are there other (better) techniques?

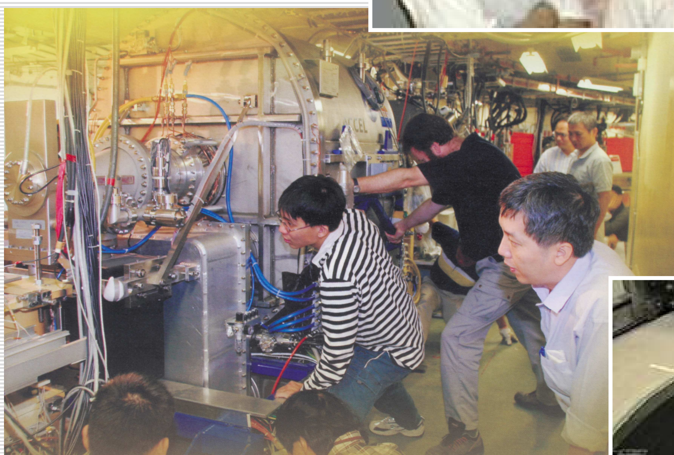
Other SRF technology challenges

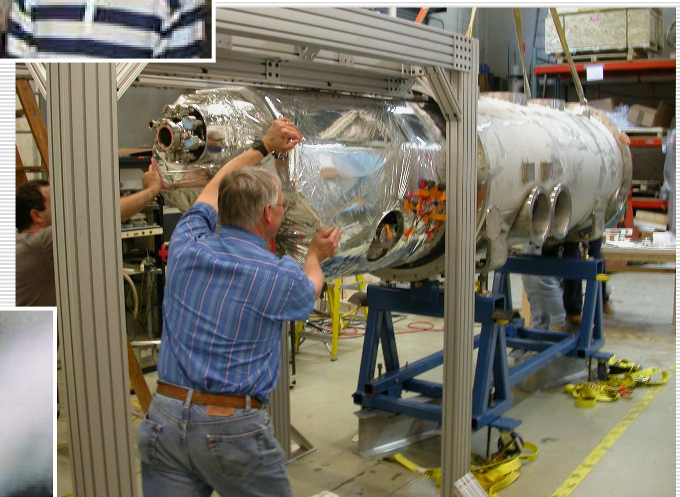
- ► Thin film technology & surface studies.
- ► Cavity treatment: new acid mixtures w/o HF?
- ► Input couplers for high average power.
- ► Alternative materials and coatings for RF windows.
- ► HOM couplers and new absorbing materials.

SRF guns

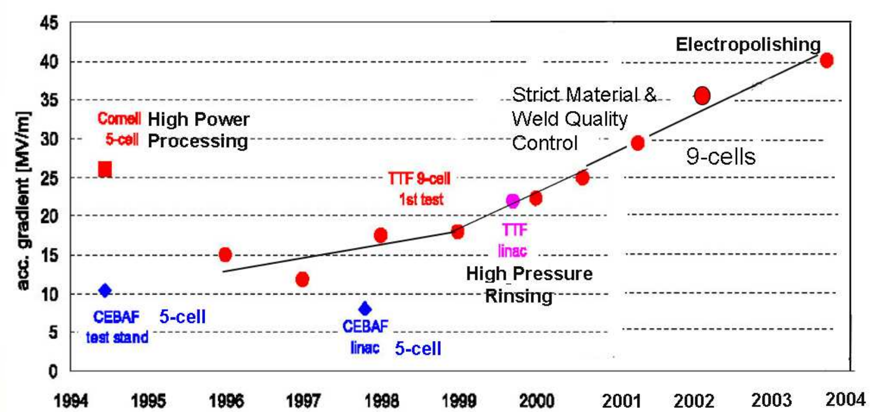

ELBE SRF Gun Cryomodule
Helium port
Liquid He Vessel
Photo cathode alignment
Cavity tuners
LASER
e-
Cathode cooling (77 K) & support system
RF power coupler
SC Nb 3½ -cell cavity
NC Cs_2Te photo cathode

SRF: hard work and a lot of fun





SRF around the world

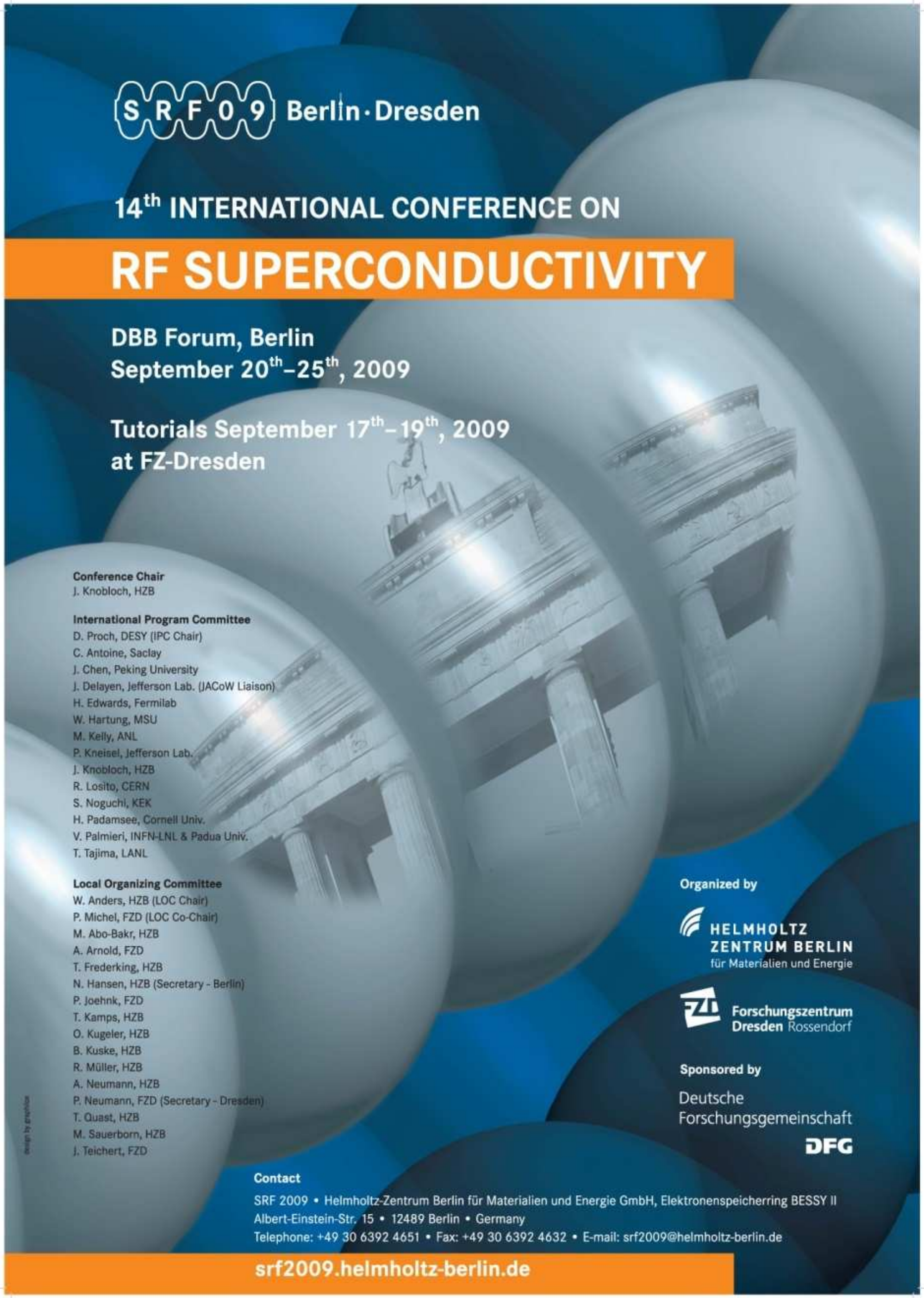


SRF 2009 conference

held at Helmholtz-Zentrum Berlin (formerly BESSY)
Sept 20th – 25th

Tutorials at FZ-Dresden
Sept 17th – 19th

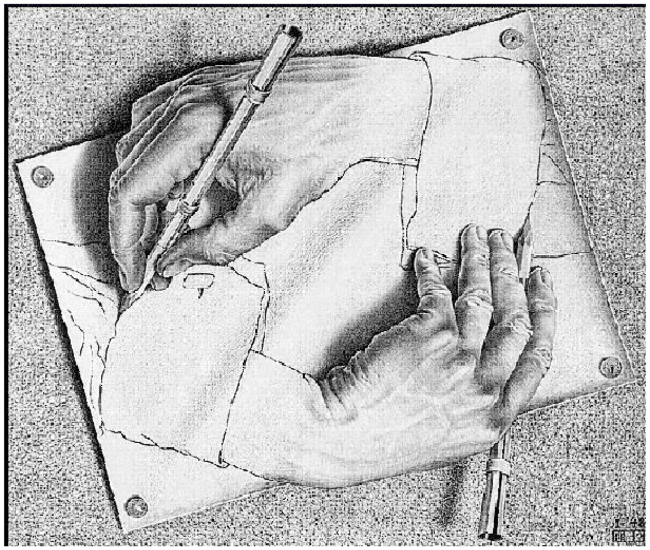
srf2009.helmholtz-berlin.de



Concluding remarks

- ✪ The field of RF superconductivity is very active.
- ✪ The technology is mature and became the technology of choice for many accelerator types.
- ✪ BUT: there are still many problems that need attention and careful investigation.
- ✪ This will require better understanding of fundamentals and technological advances.
- ✪ The design process will never be reduced to just a few simple rules or recipes.
- ✪ There will always be ample opportunities for imagination, originality, and common sense.

Cavity Design is a Work of Art and Science
Calling for Imagination, Calculation, Symmetry…..



MC Escher

See you next time at a conference or a workshop related to RF superconductivity!